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Federal Emergency Management Agency

FEMA's Flood Hazard Mapping Program

Guidelines and Specifications *for* Flood Hazard Mapping Partners

Appendix H: Guidance for Evaluating Flood Protection Systems

FEDERAL EMERGENCY MANAGEMENT AGENCY

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Appendix H

Guidance for Mapping of Areas Protected by Levee Systems

H.1 Introduction

This Appendix describes the Federal Emergency Management Agency (FEMA) requirements and procedures for evaluating earthen levee systems and mapping the areas affected by those systems. Procedures for evaluating concrete dikes, floodwalls, seawalls, and other structures are not covered herein and shall be coordinated with and approved by the FEMA Regional Project Officer (RPO) or the Project Officer (PO) at FEMA Headquarters (HQ). Mapping Partners also must contact the RPO or PO to obtain the appropriate criteria for analyzing agricultural levees.

Specific guidance for the evaluation of coastal structures and the mapping of areas affected by these structures is contained in Appendix D of these Guidelines.

H.2 Levee System Components and Terminology

A levee system usually consists of a main levee, tie back levees, a gravity outlet, and pumps. Some levee systems may also include pressure conduits, closure structures, ring levees, setback levees, sublevees, and spur levees. The most common components are defined below.

Levee: A manmade structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide protection from temporary flooding.

Levee System: A flood protection system which consists of a levee, or levees, and associated structures, such as closure and drainage devices, which are constructed and operated in accordance with sound engineering practices.

Main and tributary levees: Levees that lie along a main stream and its tributaries, respectively.

Tie back levee: Levees that extend from the main levee along a river, lake, or coast to a bluff line (high ground) and are part of the line-of-protection.

Ring levees: Levees that completely encircle or "ring" an area subject to inundation from all directions.

Setback levees: Levees that are built landward of existing levees, usually because the existing levees have suffered distress or are in some way being endangered, as by river migration.

Sublevees: Levees built for the purpose of under-seepage control. Sublevees encircle areas behind the main levee which are subject, during high-water stages, to high uplift pressures and

possibly the development of sand boils. They normally tie into the main levee, thus providing a basin that can be flooded during high-water stages, thereby counterbalancing excess head beneath the top stratum within the basin. Sublevees are rarely employed as the use of relief wells or seepage berms make them unnecessary except in emergencies.

Berm: A horizontal strip or shelf of material built contiguous to the base of either side of a levee embankment for the purpose of providing protection against underseepage and erosion, therefore increasing stability of the embankment, or reducing seepage. It can be located on either side of a levee, depending upon the berm's purpose.

Spur levees: Levees that project from the main levee and serve to protect the main levee from the erosive action of stream currents. Spur levees are not true levees but training dikes.

Dike. An embankment constructed of earth or other suitable materials to protect land against overflow or to regulate water.

Floodwall: A concrete wall constructed adjacent to a stream for the purpose of preventing flooding of property on the landside of the wall; normally constructed in lieu of or to supplement a levee where the land required for levee construction is more expensive or not available.

Line-of-protection: The location of a levee or wall that prevents flood waters from entering an area.

Pressure conduits: Closed conduits designed to convey interior flows through the line-of–protection under internal pressure. The inlet to a pressure conduit that discharges interior flows by force of gravity must be at a higher elevation than the river stage against which it functions. Some pressure conduits may serve as discharge conduits from pumping stations.

Pumping station: Pumps located at or near the line-of-protection to discharge interior flows over or through the levees or floodwalls (or through pressure lines) when free outflow through gravity outlets is prevented by high exterior stages.

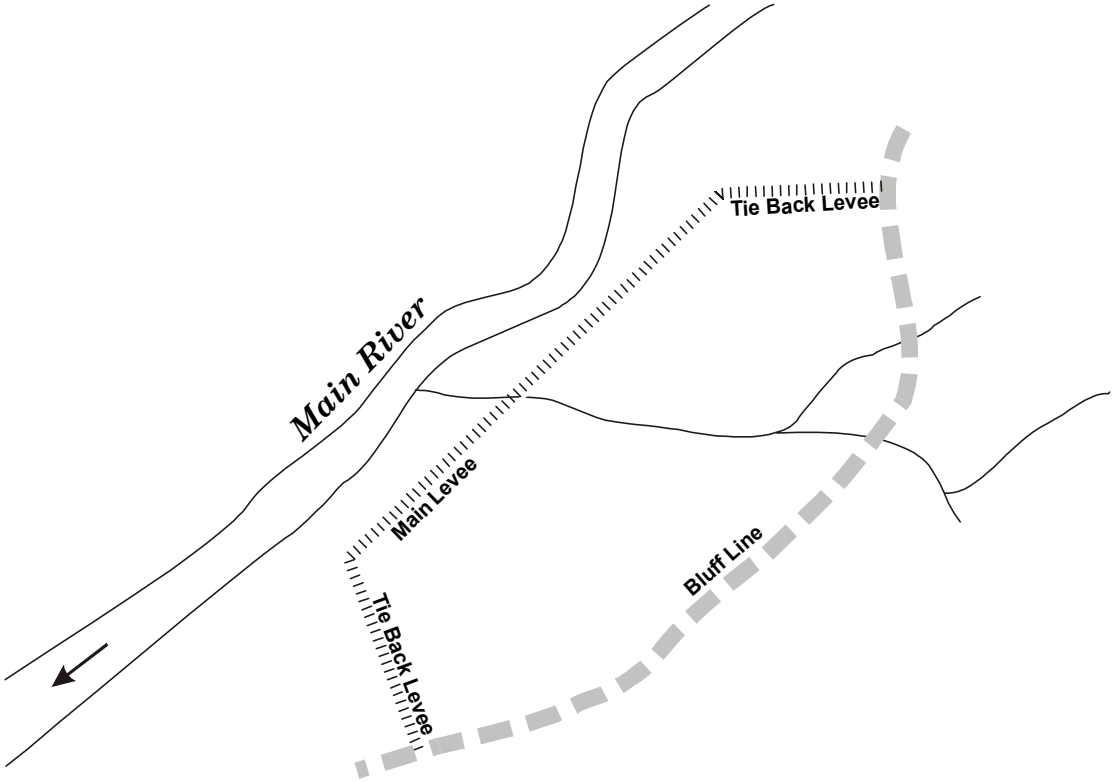
Gravity outlets: Culverts, conduits, or other similar conveyance openings through the line-of-protection that permit discharge of interior floodwaters through the line-of-protection by gravity when the exterior stages are relatively low. Gravity outlets are equipped with gates to prevent river flows from entering the protected area during time of high exterior stages.

Closure Device: Any movable and essentially watertight barrier, used in flood periods to close an opening in a levee, securing but not increasing the levee's design level of protection.

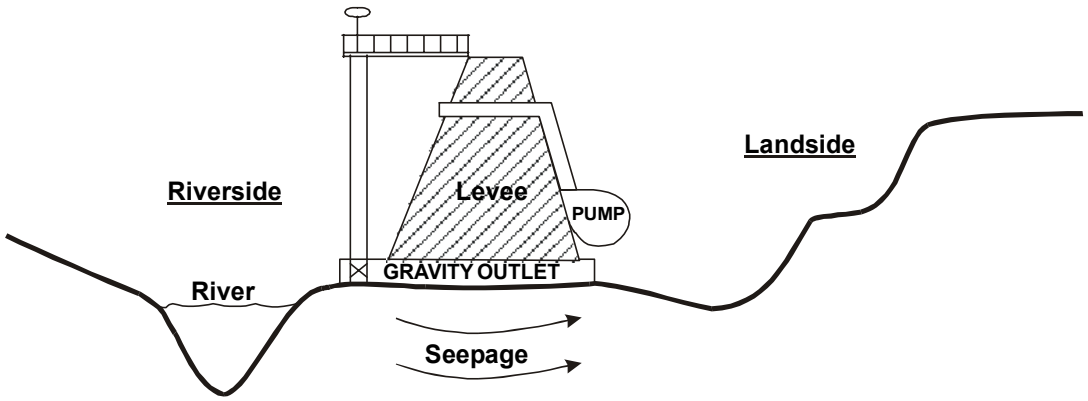
Stop log: A log, plank, cut timber, steel, or concrete beam fitting into end guides between walls or piers to close an opening in a levee, floodwall, dam or other hydraulic structure; the logs usually being handled or placed one at a time.

Street gate: A closure gate used during flood periods to close a roadway opening through a levee or floodwall.

The following diagram provides plan view and sectional view schematics of a standard levee system:



PLAN VIEW SCHEMATIC



SECTIONAL VIEW SCHEMATIC

H.3 Levee System Evaluation Criteria

In evaluating the ability of levee systems to provide protection against the 1-percent-annual-chance flood, the criteria outlined in Title 44, Section 65.10 of the Code of Federal Regulations (44 CFR 65.10) and the step-by-step procedures as summarized on the following pages should be used. The Mapping Partner should always initiate its analyses by evaluating the levee's freeboard and maintenance plan and should only proceed with further analyses if these requirements are met.

1. Freeboard. A minimum levee freeboard of 3 feet shall be necessary, with an additional 1 foot of freeboard within 100 feet of either side of structures within the levee or wherever the flow is constricted, such as at bridges. An additional 0.5 foot above this minimum is also required at the upstream end, tapering to the minimum at the downstream end of the levee. The criteria concerning freeboard are detailed in 44 CFR 65.10(b)(1).

2. Structural Design Analyses. The Mapping Partner must review the structural analyses which address closures, embankment protection, embankment and foundation stability, and settlement. The structural analyses must meet the criteria detailed in 44 CFR 65.10(b)(2),(3),(4) and (5).

3. Interior Drainage. Where credit will be given to levees providing protection from the 1-percent-annual-chance flood, the adequacy of interior drainage systems shall be evaluated. Interior drainage systems associated with levee systems usually include storage areas, gravity outlets, pumping stations, or a combination thereof. These drainage systems will be recognized by FEMA only if the criteria outlined in 44 CFR 65.10 (b)(6) and (c)(2) are met.

4. Operations. In general, levee evaluation shall not consider human intervention (e.g., capping of levees by sandbagging, earthfill, or flashboards) for the purpose of increasing a levee's design level of protection during an imminent flood. Only in exceptional cases where no practicable alternative exists and technical justification is provided, will FEMA permit sandbagging to satisfy freeboard requirements. The Regional PO must coordinate all such cases with FEMA. Human intervention will normally only be accepted for the operation of closure structures (e.g., gates or stoplogs) and manual back-up for pumping stations in a levee system designed to provide at least 1-percent-annual-chance flood protection, including adequate freeboard as described earlier. Where levee closures and/or pumping stations are involved, an officially adopted operations plan must be submitted that meets all the criteria set forth in 44 CFR 65.10(c)(1) and (2).

5. Maintenance. For a levee system to be recognized as providing protection from the base (1-percent-annual-chance) flood, the system must be maintained in accordance with an officially adopted maintenance plan, and a copy of this plan must be provided to FEMA by the owner of the levee system. The specific requirements of the maintenance plan are detailed in 44 CFR 65.10(d). Note that a governmental agency must assume ultimate responsibility for maintenance plans.

6. Certification Requirements. All levee systems must be certified in accordance with 44 CFR 65.10(e).

7. Exception Procedures. FEMA will accept certification from another Federal agency that an existing levee system is designed and constructed to provide protection against the 1-percent-annual-chance flood in lieu of the requirements outlined in 44 CFR 65.10(b)(1) through (7). Under certain circumstances, FEMA may also grant exceptions to the above requirements or approve alternate analysis techniques.

H.4 Criteria for Crediting Levee Systems on FIRMs

The Mapping Partner responsible for performing the hydrologic and hydraulic analyses shall follow the steps listed below in determining a levee system's ability to provide protection against the 1-percent-annual-chance flood. The final decision concerning the creditability of the levee system must be coordinated with the Regional PO before the Mapping Partner proceeds with further hydraulic analyses.

1. Identify the levee system to be studied, including all "levee elements" (e.g., main levee, tieback levee, railroad or highway embankment), interior drainage elements and any other elements required to form a stand-alone flood-control structure.

2. Determine the ownership of each system element via telephone contact with community officials and/or appropriate State and Federal agencies.

3. Determine the status of all system elements, as presently reflected on the effective FIRM (i.e., credited or uncredited, detailed or approximate study).

4. Obtain from the system element owner, operator (i.e., local, State, or Federal agency; or private individual or corporation), and/or the appropriate FEMA data repository, all available supporting documentation, including but not limited to "as-built" plans; survey data; geotechnical reports; structural analyses; interior drainage analyses; inspection reports; and operation and maintenance plans.

5. Obtain written confirmation of any previous certification by the agency responsible for design and construction that the levee system or elements thereof are Federal projects that provide protection from the 1-percent-annual-chance flood, when appropriate.

6. Make an individual inventory of data received for the levee system.

7. Perform hydraulic analyses of the 10-, 2-, 1- and 0.2-percent-annual-chance floods, assuming the levee system to be in place if these water-surface profiles are not available. Otherwise, assess the available computations for present-day application and modify, if necessary.

8. Use available "as-built" levee profiles or topographic data and the 1-percent-annual-chance water-surface profile obtained from the hydraulic analysis conducted with the levee in place to make a determination of the available freeboard of each system element.

9. Contact the Regional PO immediately if any element of a levee system is found to provide less than the required freeboard and notify him or her of the level of freeboard deficiency identified. Based on this discussion and the availability of other design data, the Regional PO may request

more detailed surveys of the levee profile or that a risk analysis be performed on uncertainties related to elements of levee design.

10. Review the available operation and maintenance plans to determine whether the plans conform with the requirements of Section 65.10 (c) and (d) and document in writing to the Regional PO any noted deficiencies. The Regional PO will provide guidance on any supplemental investigations necessary to ascertain the adequacy of operation and maintenance plans.

11. Summarize the results and conclusions of the above-mentioned levee investigation in a final letter report to the Regional PO and include as attachments and/or references all correspondence and reports of telephone conversations among the Mapping Partner, the Regional PO, local, State, and Federal entities, and levee owners; inventories of available data; and field inspection reports and photographs.

12. Summarize the actions taken in the investigation, the ownership of each system element, and the outcome of the investigation in the draft of the FIS Report, under the section headed "Local Flood Protection Measures."

H.5 Review Responsibilities

This section addresses the independent review responsibilities of the Mapping Partner responsible for preparing the Preliminary FIS and FIRM.

The Mapping Partner shall verify that all levees and structures intended to serve as levees for their effect on the base flood have been properly analyzed. This review shall be conducted to ensure that all minimum design criteria requirements have been met before any levee system receives recognition on the NFIP map as providing base flood protection. Any deviations or exceptions must be documented fully, and a technical basis for exceptions must be provided. This independent review shall assess the conclusions reached by the Mapping Partner performing the hydrologic and hydraulic review and shall facilitate establishing appropriate flood risk zone determinations for the FIRM, and does not constitute a determination as to how a structure or system will perform during a flood event.

H.5.1 Review Criteria

This review shall be conducted to ensure that the analysis was performed in accordance with the requirements detailed in Sections H.3 and H.4 of these Guidelines and in conformance with Section 65.10 of the NFIP regulations.

FEMA will not consider privately owned, operated, or maintained levee systems as providing protection from the base flood unless local ordinances or State statutes mandate operation and maintenance. Levee systems for which a community, State, or Federal agency has responsibility for operation and maintenance will be considered by FEMA if they meet, and continue to meet, minimum design, operation, and maintenance standards. These standards must be consistent with the level of protection sought through the comprehensive floodplain management criteria established in Section 60.3 of the NFIP regulations.

The minimum design requirements for both riverine and coastal levees that must be met, and therefore must be reviewed by the Mapping Partner, fall into the following categories: freeboard, closures, embankment protection, embankment and foundation stability, settlement, interior drainage, and other design criteria (as required by FEMA). The Mapping Partner shall review the detailed engineering analyses to be performed under each category to ensure that they comply with Paragraph 65.10(b) of the NFIP regulations. The level of effort to be expended by the Mapping Partner in reviewing levee structural design criteria shall be decided by the PO or his/her designee on a community-by-community basis.

For a levee to be recognized on the FIRM as providing base flood protection, the operation plans must comply with FEMA regulations as outlined in Paragraph 65.10(c) of the NFIP regulations. When required, the Mapping Partner shall review the plans to ensure compliance with FEMA regulations, particularly in the areas of closures and interior drainage systems.

The final criterion for levee certification is a functional maintenance plan that complies with Paragraph 65.10(d) of the NFIP regulations. The Mapping Partner shall review the plans to ensure that, at a minimum, they specify the maintenance activities to be performed, the frequency of performance, and the person(s) by name or title responsible for the performance.

It should be noted, however, that FEMA will accept certification from another Federal agency that an existing levee system is designed and constructed to provide base flood protection in lieu of the requirements outlined in Paragraphs 65.10(b)(1) through (b)(7) of the NFIP regulations. In addition, under certain circumstances, FEMA may also grant exceptions to the above requirements or approve alternative analysis techniques on a case-by-case basis.

H.5.2 Levee Inventory

In addition, to the review responsibilities detailed in Section 5 (above), all levees that have been identified and evaluated shall be documented and inventoried in accordance with the guidance provided in Volume 3, Section 3.2.7.3, of these Guidelines, which includes the requirements to prepare a Levee Inventory Data Entry Form to support the Credited Structures Inventory System (CSIS).

H.6 Floodplain Mapping and Flood Profiles

If the levee satisfies the appropriate aforementioned requirements, as verified by the Regional PO, the protected area (landward side of the levee) will be designated as Zone X or the appropriate zone determined by the interior drainage analysis such as Zone AH. If an interior drainage analysis does not exist or has been determined to be insufficient in the levee investigation, the Mapping Partner shall coordinate internal zone designations with the Regional PO.

If the subject levee does not meet the requirements stated in 44 CFR 65.10, as verified by the Regional PO, the 1-percent-annual-chance flood elevations will be recomputed as if the levee did not exist. None of the subject levee should be recognized as providing 1-percent-annual-chance flood protection unless there are portions of the levee system that can meet requirements of 44

CFR 65.10 independent of the remaining levee system. The 1-percent-annual-chance flood levels on the unprotected side of the levee will be equal to the 1-percent-annual-chance water-surface elevations computed with the levees in place.

If the 1-percent-annual-chance flood level, with the levee in place, is higher than the top of the levee, the computed 1-percent-annual-chance flood levels should be used on the river side of the levee. The 1-percent-annual-chance flood levels will then be recomputed for the landward side of the unrecognized levee as if the levee did not exist.

If water-surface elevations of the other floods (10-, 2-, and 0.2-percent-annual-chance) are higher than the top of the levee elevations, they will also be considered equal to the top of the levee on the unprotected side. If these elevations are lower than the top of the levee, they will be shown as computed on the profile. Further analyses for the conditions without the levees should not be made for frequency floods less than the 1-percent-annual-chance.

For the levees that do not satisfy the minimum requirements, a maximum of five flood profiles might be drawn on the profile sheet representing the 10-, 2-, and 1-percent-annual-chance flood with levee, and the 1- and 0.2-percent-annual-chance flood without levee elevations.

If the "with levee" 1-percent-annual-chance (base) flood elevations (BFEs) are higher than the "without levee" BFEs, the FIRM should show a line running along the levee centerline, separating the areas of different BFEs. Otherwise, only "without levee" BFEs will be shown.

The floodway widths will be computed for the "without levee" condition if the levees do not meet the requirements of 44 CFR 65.10. The equal conveyance reduction method should be used. The "Regulatory" column in the Floodway Data table will show two BFEs, representing "river side" and "land side" conditions, if the former elevation is higher than the latter elevation. Otherwise, "without levee" BFEs will be shown. At a tributary's confluence with the main stream, BFEs from the main stream will be shown as the regulatory elevations if they are higher than the "river side" or "land side" BFEs of the tributary.

The above procedures for the determination of profiles and floodways can also be applied to the conditions where levees exist on both sides of the stream. If levees exist on both sides of a stream, the evaluation of levee systems must consider the possibility of simultaneous levee failure, failure of only the left side, and failure of only the right side. Simultaneous levee failure should be considered for profile and floodway computations.

Floodways will be delineated at the landside toe of mainline and tributary levees that are recognized as providing 1-percent-annual-chance flood protection on a FIRM. Thus, the community's floodplain management ordinance will prohibit encroachment upon the levee, which could jeopardize the levee's integrity or effectiveness. It may also be appropriate to place floodways at levees providing a lower level of protection if encroachment on the river side of the levee is of concern to the community. The Mapping Partner should consult with community officials and the Regional PO in resolving this situation.

For levee systems where an area of land may be totally or partially surrounded by levees or where two or more flooding sources join that have levees on both sides of the stream, the Mapping Partner should contact the Regional PO before proceeding with any analyses for levee failures. For these complex situations, the flood hazard in the area that would have been protected by the non-failed levee(s) should be based on selection of failure scenarios that yield the highest BFE or flood hazard.

H.6.1 Flood Control Restoration Zones

Where the flood hazard Mapping Partner evaluating a levee system on a FIRM determines that a community is in the process of restoring its flood protection system to provide protection against the 1-percent-annual-chance flood, the Partner shall follow the procedures outlined and request the information required by FEMA in Part 65.14 of the NFIP regulations. If the criteria of Part 65.14 are met, the mapping partner shall coordinate with the RPO to determine if the FIRM should designate the temporary flood hazard areas as a flood control restoration zone (Zone AR).

Where the flood hazard mapping partner evaluating a levee system on a FIRM determines that a community, that receives Federal funds for the purpose of designing and/or constructing a flood restoration project, obtains written evidence from a Federal agency having flood protection design or construction responsibility that necessary improvements have been made to the system to restore protection from the 1-percent-annual-chance flood, the partner shall coordinate with the RPO to determine if the flood control restoration zone designation should be revised to Zone A99. The criteria outlined in Part 65.14(h) of the NFIP regulations shall be the basis for this determination.